# X-RAY FLUORESCENCE MICROPROBE (XFM)

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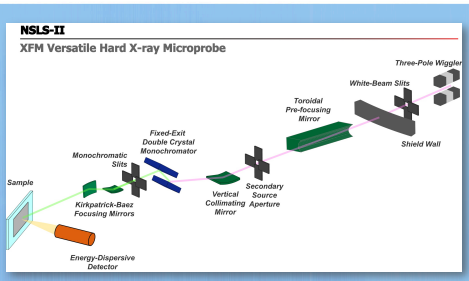
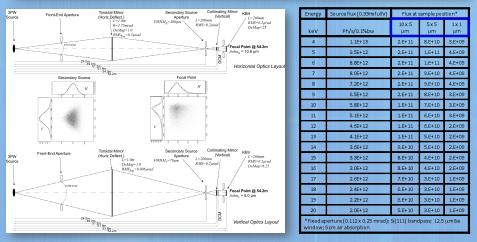
BROOKHAVEN NATIONAL LABORATORY

NATIONAL SYNCHROTRON LIGHT SOURCE II planned by Photon Sciences Directorate

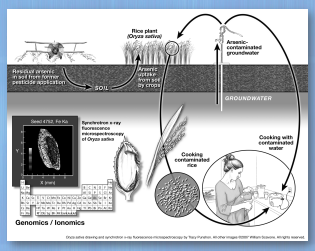
## TECHNIQUES AND CAPABILITIES

- XFM is an optimized three-pole wiggler beamline for the characterization of materials in an "as-is" state that are chemically heterogeneous at the micrometer scale via synchrotron induced X-ray fluorescence.
- XFM includes instrumentation for microbeam X-ray fluorescence (μXRF), diffraction (μXRD) and fluorescence computed microtomography (FCMT) . However, it is optimized to provide users state-of-the–art microfocused Extended X-ray Absorption Fine Structure (μEXAFS) spectroscopy between 4 to 20 keV.
- XFM will trade-off beam size and flux for sample configuration flexibility. This includes more readily achievable stability constraints for spectroscopies (μEXAFS), accommodating large sample sizes (up to meters), and provisions for customized environmental chambers.

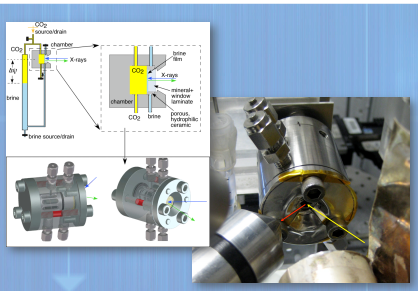


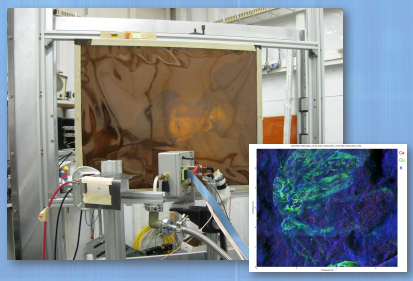
## APPLICATIONS




- XFM will provide the NSLS-II user community an optimized beamline for studying the genetic control of metal ion uptake, transport and storage in plants relevant to agriculture and bioenergy.
- The only beamline in the world designed to directly support plant biochemistry, XFM will provide high-throughput and high-resolution whole-plant fCMT.
- fCMT provides a 3D non-invasive, spatially resolved and multi-elemental analysis technique that images the metal concentration of specific cell layers and organelles in plants as close to their natural state as possible.




- XFM's unique optical design, which allows it to maintain a small spot size at long working distances with high flux and at high energies, will provide an ideal platform for microfocused analysis of samples within environmental cells.
- For example, we are designing cells for XFM that allow users to analyze materials under *sc*$CO_2$ confinement (T > 31°C, P > 7.4 MPa), while controlling ΔP.
- XFM will utilize in-situ μXRF, μEXAFS and μXRD to quantify hydraulic/transport properties of brine films confined by $CO_2$ under geologically relevant conditions.



- Imaging large samples at X-ray microprobes is impractical, but XFM with its variable focus and collimation and advanced ultrafast, large solid-angle EDS detectors being developed at BNL, is ideal for these studies.
- XFM will allow for signals from 100's of elements to be read at milliseconds per pixel for bidirectional scans covering meters!
- Large format translation stages and environmentally-controlled hutches will allow for analysis of whole objects including panel paintings, sculpture, paleontological and archaeological materials.
- XFM will be the focus of such work for museum scientists in the northeastern U.S.

## WORLD-LEADING MICROFOCUSED EXAFS SPECTROSCOPY

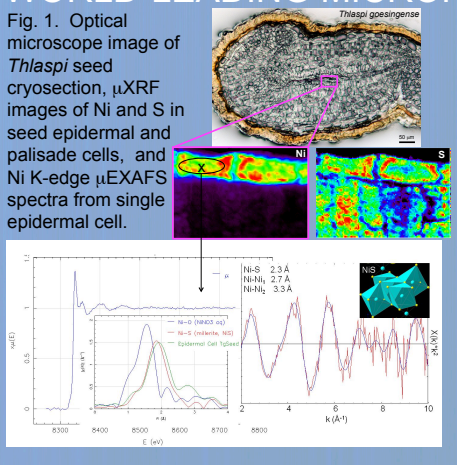



Fig. 1. Optical microscope image of *Thlaspi* seed cryosection, μXRF images of Ni and S in seed epidermal and palisade cells, and Ni K-edge μEXAFS spectra from single epidermal cell.

- XFM's unique optical design is optimized to enhance NSLS-II's source stability to provide unmatched μEXAFS data quality. Specifications include:
  - ➢ Use of a toroidal focusing mirror to illuminate a virtual source on the experimental floor that will be collimated, monochromated and imaged with KB microfocusing mirrors.
  - ➢ μ(E) oscillations measured to <0.1% of the edge-step signal for transition metals at >10 ppm concentration in a 1-10 μm spot.
  - ➢ Focused beam stability of <5% of the beam area while scanning a 1 keV energy range.
  - ➢ Fixed-exit DCM with user-selectable Si(111) and Si(311) crystal-pairs on a broadband source, will permit general user's to seamlessly and efficiently configure the beamline for spectroscopy in the 4-20 keV range.